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Full Length Research Paper

Effects of rice cultivation on Ndokwa East grassland soils in Delta State, Nigeria

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The study examines the effects of rice cultivation on soils of Ndokwa East grassland, with the aim of determining the effects of rice cultivation on physical and chemical properties of soils. Soil samples were collected from two experimental sites namely cultivated and uncultivated plots in the study area. Eighteen (18) plots were marked at 60m × 60m and subdivided into quadrants of 1m × 1m for data collection, soil samples were collected with most probable instruments and analyzed for physical and chemical properties in the soil. The result from the analysis revealed that rice cultivation has effects on soils of Ndokwa East grassland. The study also revealed that the combination of slash and burn, tillage and soil amendments techniques has enhanced soil nutrient reserve. The result from the t-test analysis showed t value of 7.642, indicating significant effects of rice cultivation on soils of Ndokwa East grassland. The study further recommended the application of organic/inorganic manure and liming to breast up soil nutrient and reduces soil acidity. Moreover, the incorporation of rice straw into the soil should be encouraged to enhance soil fertility in Ndokwa East grassland soils.

Key words: Soil, rice, cultivation, Ndokwa East, grassland.

INTRODUCTION

Soil is the major component of the environment, as well as a major resource of the earth with a lot of potentials, and it has been described by Ahn (1978) as the basis of human civilization. The role of soil in food productivity cannot be over emphasized. However, Ashaye (1978) described soil as the great provider of food, which in turn, the bedrock of civilization. Areola (1990) asserted that no nation can be stronger than its agriculture. But agricultural development depends more than anything else, on the ability of a nation to conserve and exploit fully the potential productivity of its soils.

However, in recent years, this valuable resource of the environment (soil) with precious biological diversity has been threatened by unproductive agricultural practices, with its attendant effects on soil nutrient reserves and crop yield (Akinbode, 2002). This is because the physical, chemical and biological properties of the soil is disrupted and its productivity of crops may decline with time and thus, threatening the fundamental role of soil as the principal source of essential elements for crop productivity (Areola, 1990). The physical and chemical characteristics of the soil determines such essential quality of land, for example, its ability to supply water and nourishment to plants, provisions of mechanical support and construction materials for all living things, including man. The soil also, is the repository of much of our waste products both from the home and at work place. Its ability to break down or purify these waste products and resynthesize new product from them, is one of the most important life sustaining functions of the soil in earth environmental system (Bongfen, 2006). Soil in its natural state and under the protective cover of natural vegetation is described to be in a fertile condition. But as man begins to make use of soil, its structural and functional balance is disrupted. This is because the fertility of the soil is easily exploited and its structural stability destroyed by human activities (Peters, 2001). However, since the soil is a maintainable resource with a natural ability to rebuild its structure and recoup lost fertility, its productivity can often be sustained with proper management practices (Ugboma, 2007).

Farming is the most important occupation in Ndokwa East area. The natives, who are mainly farmers, cultivate rice in the grassland soils of the area. The grassland which exists in patches used to be regarded as 'waste land' by the natives who are mainly subsistence farmers. Moreover, in recent years, the area has been experiencing rapid population growth sequel to the influx of people into the area, and this has caused shortage of farmlands (Peters, 2001). Consequently, farming activities started encroaching onto the grassland areas, and this marked the commencement of agricultural activities in the savanna areas of Asemoku, Ossissa and Beneku in Ndokwa East.

The soil management methods adopted by the farmers in the cultivation of rice are long fallow system, slash and burn technique, tillage system and the use of soil amendments. Considering the obvious success of the peasant producers of rice and their crucial role in the local economy, the bumper harvest usually experienced by the farmers in many parts of Ndokwa East area where grassland patches exist, is fast disappearing following the low yield of the crop. It was observed by the farmer that despite the various soil management practices adopted, there is still a steady decline in the yield of the crop even with the application of fertilizers (Peters, 2001). The question that agitates their mind is that which is the best soil management techniques that can be adopted in the grassland to enhance the yield of rice in the area? Thus the study aimed at assessing the effects of rice cultivation on the physical and chemical properties of soils in Ndokwa East grassland in order to ameliorate the problems of low yield of rice in the area.

Study area

The study area is located in the south-eastern part of Delta State in the South-South zone of Nigeria. It lies between latitude 5°45' N to 6°01'N and longitude 6°06'E to 6°20'E, it is bounded by the River Niger on the east, Isoko North Local Government Area in the south, Ughelli North, Ethiope West, Ika North and South, Aniocha South and Oshimili South Local Government Areas to the North. Ndokwa East lies in the coastal plain of Southern Nigeria (Figure 1). The grassland is gently undulating plain without even a single hill rising above the general land surface. The mean elevation of the area is generally below 50 m above sea level (Okpor, 2002).

The study area is part of Niger Delta and it is underlain by sedimentary rocks, consisting mainly of yellow and white sand with pebbles, clay and sandy clay occur in lenses (Aweto, 1998). Three geological formation of Benin, Agbada and Akata formations occur in the area and they lay one below the other. The soil is deeply weathered, deeply reached, friable, and they lack distinct and well defined horizons. The soil has low silt and clay content, low cation exchange capacity and consequently low pH (Okpor, 2002). The annual mean temperature is about 27°C, and the mean annual rainfall is 2540 mm with September being wettest month (485.39 mm) and January is the driest month (33.27 mm). Relative humidity of the air is high throughout the year (Okpor, 2002).

The natural vegetation of Ndokwa East is the tropical rainforest. The plant community is basically of evergreen species that yield hardwood e.g., *Entaudrophragma* spp., *Melicia excelsa, Khaya invorensis, lovoa trichilodes* etc, but because of anthropogenic activities, there is the emergence of grassland vegetation in many areas of Ndokwa East, mainly in patches. The grassland has encouraged the practice of rice cultivation in Ndokwa east area in Delta State.

MATERIALS AND METHODS

Soil samples were collected from rice cultivated plots, and other sets of soil samples were collected from uncultivated plots that served as control. The three locations of grassland patches in the study area were each stratified into three divisions. 18 equidistance plots, 9 each from cultivated and uncultivated plots were marked out at 60m × 60m apart from which soil samples were collected for a period of 6 months. The plots were further divided into quadrants of 1m × 1m, and soil samples were randomly collected from a predetermined depth of 0-10 cm layer from the topsoil being the threshold of rice cultivation. A total of 18 soil samples were collected with 9 soil samples each from cultivated and uncultivated plots. The mean of these soil samples were determined and used for the study. The samples collected were placed in a labeled polythene bags before taken to the laboratory for further processing and analysis.

Soil bulk density was estimated from samples collected from cultivated and uncultivated plots and was determined on cores (Black, 1965). The soil samples were immediately weighed before transportation to the laboratory for oven drying at 150°C for 24 h and re-weighed. Bulk density was then calculated as an oven dry mass (mg) per volume (m^3). Total porosity values were calculated from the bulk density figure using an assumed particle density of 2.65 cm^3 (Vomocil, 1965). With the exception of soil samples collected for density determination, all other soil samples were air-dried at room temperature and passed through a 2 mm sieve and analyzed for particle size composition by hydrometer method (Bouyoucos, 1962). Organic carbon was analyzed by chromic acid digestion method (Walkley and Black, 1934), total nitrogen by regular micro-kjeldahl method, and available phosphorus by Bray PI method. Soil pH was determined potentiometrically in distilled water using a soil ratio of 1:1 (Bates, 1964).

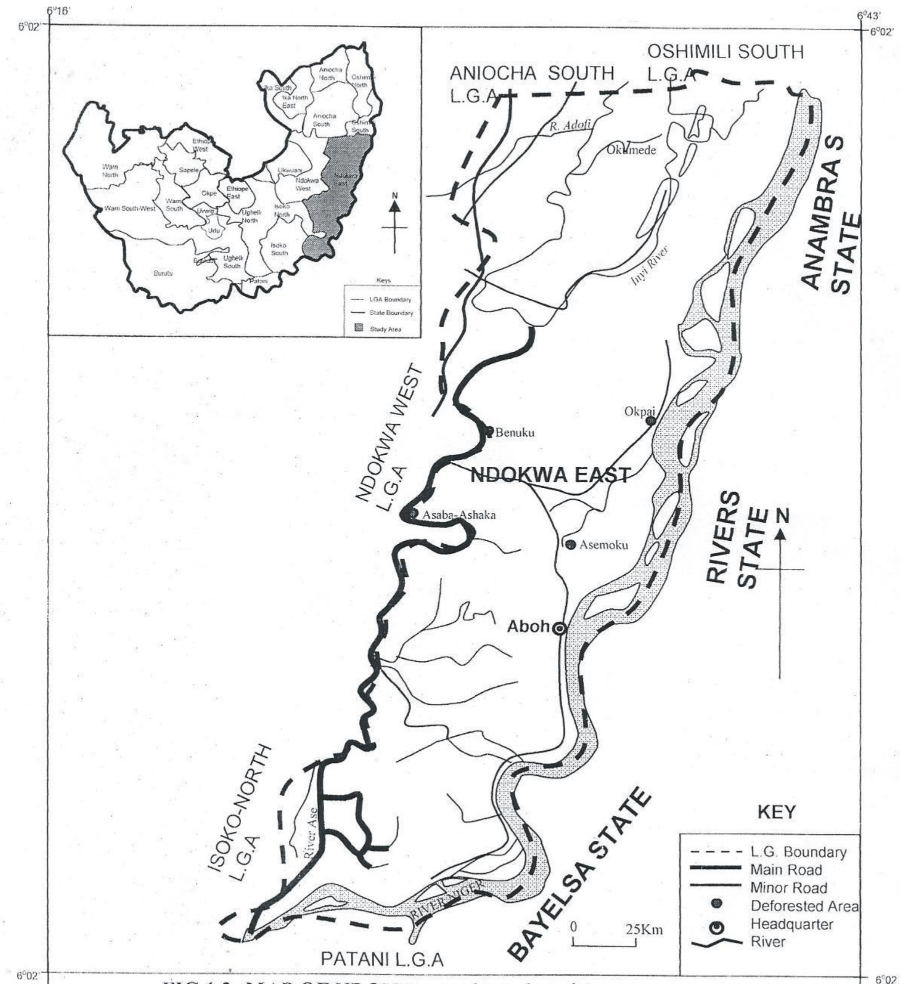

Figure 1. Map of Ndokwa East L.G.A showing study locations. Source: Ministry of Lands, Survey and Urban Development Asaba (2004).

Student t-test analysis was adopted to ascertain if a significant difference exist between the two sets of soils from cultivated and uncultivated plots in Ndokwa East grassland: this was done with the view of determining the effects of rice cultivation on the grassland soils.

RESULTS AND DISCUSSION

Table 1 showed the mean values of physico-chemical properties of soils under cultivated and uncultivated plots in Ndokwa East area. The mean values of sand, silt and clay are 85.6, 7.3 and 7.1% of rice cultivated plots, while those for uncultivated plots are 81.2, 8.2 and 7.9% for sand, silt and clay, respectively. This distribution shows that soils under cultivated and uncultivated plots are predominantly sandy, and texturally homogeneous. This is to be expected since the soils are derived from the same parent material (Aweto, 1998). The mean values for bulk density and total porosity are 1.02 g/cm^3 and 61.56% in rice cultivated plots while those of uncultivated plots are 0.79 g/cm^3 and 69.91%. This distribution shows that soil under uncultivated plots have better physical status than those under rice uncultivated plots; because they are less dense or compact and more porous. This is presumably because in cultivated plots, grasses grow in tussocks and have greater cover than the cultivated plots (Aduayi, 1985). The variation might also be due to tillage prior to cultivation, leading to organic matter diminution (Aweto, 1998). The implication of reduction in porosity in cultivated plots, leads to a lower permeability that results in loss of soil nutrients and deterioration in soil physical status. The mean value of pH for cultivated plots is 4.3 while that of uncultivated plots is 4.9. The lower pH observed in rice cultivated plots implies that rice crop makes greater demand on soil nutrients, such as calcium and magnesium, than those of uncultivated plots (Bongfen, 2006). Furthermore, the high value of pH in uncultivated plots can be attributed to occasional burning of the grassland (Bongfen, 2006). The mean value of organic carbon and total nitrogen for rice cultivated plots

Table 1. Mean of physcio-chemical properties of soil under cultivated and uncultivated plots.

Soil properties	Uncultivated plots		Cultivated plots		Loss
	Range	$\bar{x}$	Range	$\bar{x}$	
Sand%	77.8-84.4	81.2	83.2–83.3	85.6	4.4
Silt %	7.0 – 9.6	8.2	5.56 – 9.2	7.3	0.9
Clay%	7.0 - 8.6	7.9	6.16 - 7.6	7.9	0.8
Bulk density (g/cm3)	0.78 – 0.81	0.79	1.00 -1.02	1.02	0.23
Total porosity %	69.51 – 70.21	69.91	60.91-62.34	61.56	8.35
Soil pH (in water)	4.8 – 4.96	4.9	4.2 – 4.12	4.3	0.6
Organic carbon %	1.7 – 3.34	2.33	1.50 – 1.67	1.54	0.79
Total nitrogen %	0.16 - 0.21	0.18	0.23 - 0.27	0.26	0.08
Available Phosphorus ug/g	4.58 - 6.80	5.96	4.58 - 7.80	5.97	0.01
CEC	4.21 – 5.17	4.7	2.97 - 3.99	3.2	1.5

Source: Field survey, 2010.

Table 2. Pair Sample statistics.

Pair 1	Mean	Std. deviation	Std error	95% confidence interval of difference		t	df	Sig (2-tailed)
				Lower	Upper			
Uncultivated	17.43	7.423	2.534	9.896	22.51	7.642	4	0.001
Cultivated	34.61	5.329	1.863					

are 1.5 and 0.26% while that of uncultivated plots are 2.33 and 0.18%. The greater cover of uncultivated plots could not have made much impact with regards to addition of more organic matter to the soil because of occasional burning of grassland during dry season, while rice straw are left to decay into the soil in cultivated plots at each cultivation; organic matter accumulates more in the first 20 cm of the surface soil. Although, it is conventional to aim at soil organic matter of between 1.5 to 5% in order to maintain soil fertility (Aduayi, 1985). While the difference in total nitrogen between cultivated and uncultivated plots arose was probably because the grass species makes greater demands of nitrogen than rice plants. Ugboma (2007) observed that nitrogen content of weeds was significantly higher than that of rice straw, thus the mean values of available phosphorus and CEC for rice cultivated plots are 5.97 ug/g and 3.2 (me/g), while that of uncultivated plots are 5.96 ug/g and 4.7 (me/g). The distribution of phosphorus shows that the value obtained in cultivated plots is slightly lower than that of uncultivated plots. This indicates that rice cultivation have adverse effect on phosphorus (Vine, 2003). The distribution of CEC showed that cultivated plots had lower value, and this can be attributed to the fact that a substantial part of the nutrients in inorganic fertilizers applied to the soil are been leached away during cropping (Okpor, 2002). Generally, the CEC of both rice cultivated and uncultivated plots are low in Ndokwa East area, as it falls below the required range of 12-25 me/100 g as asserted by Aduayi (1985).

Table 2 showed that the mean value of uncultivated plots is 34.61 (SD=5.329) while that of cultivated plots is 17.43 (SD=7.423), indicating the effect of rice cultivation on soil fertility in cultivated plots. The table further revealed that the calculated t value of 7.642 is greater than the critical table value of 2.843 at $p < 0.05$ and thus, the model is significant. The result reveals that rice cultivation has a significant effect on Ndokwa East grassland soils.

Conclusion

The study examined the effects of rice cultivation in Ndokwa East grassland soils in Delta State of Nigeria. The study revealed that rice cultivation has a significant effect on soil fertility. However, the introduction of soil management measures such as the fallow system, tillage system and use of soil amendments has improved significantly the nutrient status of the soil. The application of organic/inorganic manure and liming as a measure to breast up soil nutrient reserve and reduce soil acidity is important.

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